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Numerical Shape Coefficient of Shear Deformation for Mindlin Plate on Phase Velocity of Transverse Elastic Waves

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1. INTRODUCTION

In this paper, numerical shape coefficient of shear deformation for a rectangular plate is determined based on the first mode curve of the phase velocity for transverse elastic waves obtained from Timoshenko [1] .

2. PHASE VELOCITY

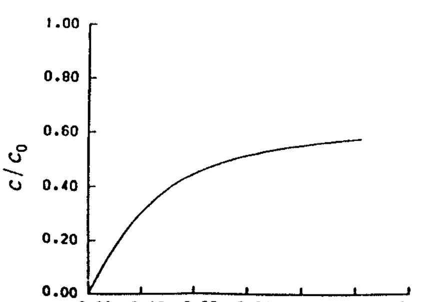
The first mode curve of phase velocity obtained from Mindlin Plate Theory [2] can be found as follows.

$$\frac{c}{c_0}=\frac{2\sqrt{\frac{2}{3}}(\pi p)}{\left[(1-\nu^2)+\frac{4}{3}(a+1-\nu^2)(\pi p)^2+\left\{(1-\nu^2)^2+\frac{8}{3}(1-\nu^2)(a+1-\nu^2)(\pi p)^2+\frac{16}{9}(a-1+\nu^2)^2(\pi p)^4\right\}^{\frac{1}{2}}\right]^{\frac{1}{2}}}$$

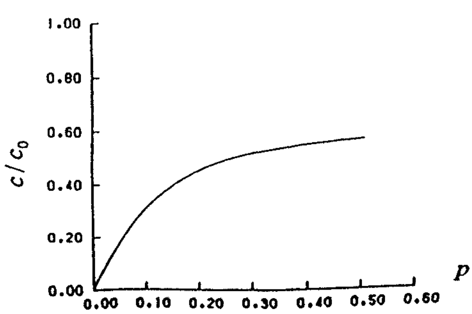
where $c=\frac{\omega}{\gamma}$, $c_0=\sqrt{\frac{E}{\rho}}$, $\gamma=\frac{2\pi}{\lambda}$, $a=\frac{E}{kG}=\frac{2(1+\nu)}{k}$, $p=\frac{\frac{h}{2}}{\lambda}$, c =phase velocity, ω = angular frequency, γ =wave number of transverse elastic waves, λ =wave length of transverse elastic waves, E =modulus of longitudinal elasticity of the beam, G = modulus of shear deformation, ν = Poisson's ratio, ρ = density, k =numerical shape coefficient of shear deformation, h =height of rectangular plate.

3. COMPUTATIONS

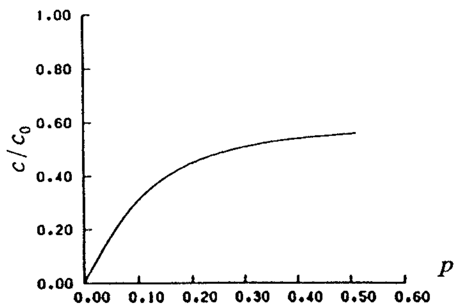
In Figure 1, results of the present authors' computations according to plane strain of two- dimensional elastic theory [1] are compared with those according to Mindlin's theory. The real line is the first mode curve of phase velocity obtained from plane strain of two-dimensional elastic theory, and the dotted line is that obtained from Mindlin Plate Theory. In each case of (a)-(f), giving the numerical value of ν first, computations have been repeated untill a suitable value of k is found out with which two lines well coincide with each other, by changing the value of k little by little.



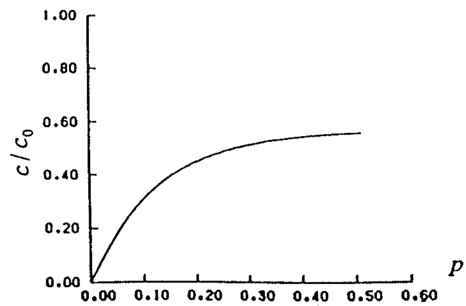
(a) ν = 0.1, k = 0.850



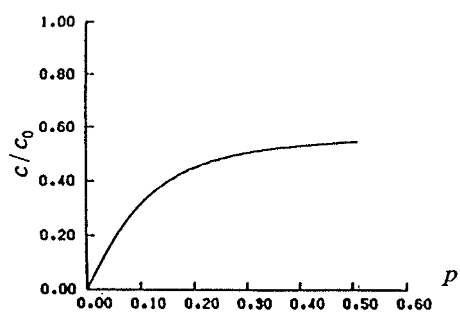
(b) ν = 0.2, k = 0.875



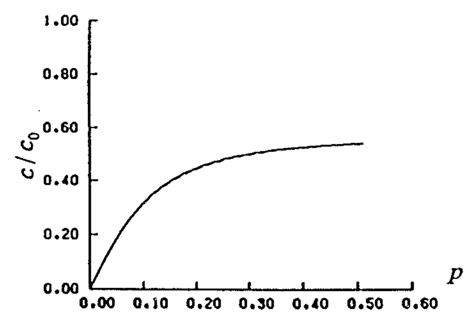
(c) $\nu = 0.25, k = 0.885$



(d) $\nu = 0.30, k = 0.895$



(e) $\nu = 0.35, k = 0.905$



(f) $\nu = 0.40, k = 0.915$

Figure 1. First mode curves of phase velocity computed from plane strain of two-dimensional elastic theory and Mindlin's theory

4. CONCLUSIONS

Numerical shape coefficient of shear deformation for a rectangular plate depends on Poisson's ratio. For the suitable k, the real line and the dotted line well coincide with each other.

REFERENCES

1. S. P. TIMOSHENKO 1922 Philosophical Magazine and Journal of Science 43,125-131 On the Transverse Vibrations of Bars of Uniform Cross-Section.

2. R. D. MINDLIN 1951 Transactions of the ASME. Journal of Applied Mechanics 18,31-38. Influence of Rotatory Inertia and Shear on Flexural Motions of Isotropic, Elastic Plates.